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Impacts of land use and land use changes on the resilience of beekeeping in Uruguay

Arttu Malkamäki [a,*], Anne Toppinen [a], Markku Kanninen [b,c]

[a] University of Helsinki, Department of Forest Sciences, P.O. Box 27, 00014 Helsinki, Finland
[b] University of Helsinki, Viikki Tropical Resources Institute, P.O. Box 27, 00014, Helsinki, Finland
[c] Center for International Forestry Research, P.O. Box 0113, 16000 Bogor, Indonesia

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ABSTRACT

We use a social-ecological systems framework and interview data from key informants to analyze the threshold dynamics underpinning the resilience of the local beekeeping sector, amidst changes in land use (management) and land use changes (conversions) that result from the expansions of the soy and eucalypt frontiers in Uruguay. Our results indicate that while agriculture began displacing grasslands that originally provided high yields of honey, afforestation now compensates those losses through the flowerings of *Eucalyptus grandis*. By extending the flowering season from six to eight months, beekeepers' dependency on tree plantations has increased. However, forestry enterprises are now shifting to plant more productive species that do not flower similarly, anticipating a threshold crossover to which the beekeepers may be unable to adapt. In conclusion, resilience of this environmentally sensitive livelihood has been suppressed primarily by land use changes that have introduced new costs and challenges into honey production. However, threshold dynamics that appear as multifaceted challenges faced by beekeepers occur also elsewhere in the system. Certain outcomes of the threshold dynamics similar to feedback loops in social-ecological systems were identified, including considerations of out-migration and change in occupation, of which ultimate impacts remain unclear. Most beekeepers still cope with the remaining viability, but it appears that the current resilience level does not allow for further harmful impacts. This case example of coupled social and ecological interactions through a livelihood lens gives rise to future research in evolving new dimensions to govern social-ecological systems in Uruguay and beyond.

1. Introduction

Frameworks encompassing social-ecological systems have become popular in analyzing the cross-scale interactions between the coupled, coevolved, and reciprocal social systems (i.e. people and their needs) and ecological systems (i.e. nature and its exploitation) to address the most pressing sustainability challenges (Binder et al., 2013; Cash et al., 2006; Holling, 2001; Liu et al., 2015). While some frameworks aim to diagnose the nonlinear interactions and outcomes to allow relevant actors to make more conscious choices under uncertainty (e.g. McGinnis and Ostrom, 2014), others have shifted the focus of sustainability analyses from pursuing optimal states and maximum sustainable yields to resilience analyses (Anderies et al., 2004; Domptail et al., 2013; Folke et al., 2002; Walker et al., 2006, 2004). In this paper, the concept of resilience holds relevance.

Resilience refers to the ability of an actor (in case of social resilience) or an ecosystem (in case of ecological resilience) to counter external stressors and reorganize from a shock without losing its distinctive features (Adger, 2006, 2000; Folke, 2006). Adaptability would refer to the capacity of an actor or an ecosystem to influence resilience without an external intervention (Walker et al., 2004; Vincent, 2007). Importantly, resilience implies changing productive and organizational patterns for absorbing disturbances, but only for as long as irreversible thresholds are not crossed (Folke et al., 2004; Walker and Meyers, 2004).

Ecological thresholds are linked to discrete disturbances or the accumulation of harmful impacts, and they are used to indicate the breakpoint between two alternate regimes that may have drastic impacts on ecosystem functioning (Folke et al., 2004; Renaud et al., 2010). For example, empirical research has shown that a certain level of habitat fragmentation reduces biodiversity in a forest (e.g. Andrén, 1994; Fahrig, 2003). Several examples of such ecological regime shifts that are often related to social standards exist (e.g. pollution or overexploitation), including rangelands, coastal waters, and lakes (Anderies et al., 2002; Bestelmeyer, 2006; Carpenter et al., 2001; Rönnberg and Bonsdorff, 2004).

Discussion around thresholds has recently focused on social thresholds that are crossed when the acceptable conditions turn into unacceptable conditions (Christensen and Krogman, 2012). Shrinking trust

* Corresponding author.
E-mail addresses: arttu.malkamaki@helsinki.fi (A. Malkamäki), anne.toppinen@helsinki.fi (A. Toppinen), markku.kanninen@helsinki.fi (M. Kanninen).

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in a collective management system could exemplify an approaching social threshold (Walker et al., 2006). Crossed thresholds can be examined through the feedback loops that are reflected in the social (e.g. changes in institutions) or ecological (e.g. reduced functioning) system. Such attempts are constrained by the fact that thresholds in complex social-ecological systems are dynamic and in constant interaction with each other (Folke et al., 2004; Walker and Meyers, 2004), but weakening resilience due to human or natural activity has been associated with an increased probability of nonlinear regime shifts (Scheffer et al., 2001). Transformability would refer to the capacity of an actor to create a fundamentally new system when thresholds are crossed (Walker et al., 2004).

Understanding resilience and thresholds is relevant for sensitive human populations that disproportionately rely on natural resources. Crossing of thresholds also tends to constrain adaptability by delivering new costs and challenges to such populations, in line with the feedback loops associated with regime shifts (Janssen and Scheffer, 2004; Moser and Ekstrom, 2010; Mwangi and Ostrom, 2009; Zenteno et al., 2014). Equally important is to identify fast (e.g. weather, seasonal yields, and technology) and slow (i.e. controlling, e.g. climate, genetics, soil, and culture) variables that trigger thresholds (Walker et al., 2012). In theory, ecosystem managers should be interested in both fast and slow variables, and awareness of the impacts of approaching regime shifts could thus alter the course of management (Christensen and Krogman, 2012; Walker and Pearson, 2007). Warning indicators can be developed to anticipate thresholds, but precision of such indicators has remained poor (Adger, 2006; Biggs et al., 2009).

This conceptual framework suits the context of Uruguay, where the intensifying land use (i.e. management) and land use changes (i.e. conversions) have become highly visible in the last two decades, and are driven by the economic forces underlying agriculture and afforestation (Fig. 1). Landscapes in Uruguay have experienced a constant change since the 19th century, when grazing began mixing in with the native shrubs and pampa grasslands (Brussa and Grela, 2007; Eva et al., 2002). According to latest census data from 2011 (DIEA, 2015), however, agriculture expanded from 4.1% of land area in 1990 to 9.2% in 2011. Afforestation increased from 1.1% to 6.1%. These numbers only tell part of the story: agriculture has been characterized by soy plantations that expanded from 0.883 M ha in 2011 to 1.321 M ha in 2013; afforestation by eucalypt plantations that increased from 0.676 M ha to 0.726 M ha (MGAP, 2015). The expansions have largely come at the expense of grasslands (Tommasino, 2010). Besides these changes in resource systems, annual precipitation has increased since the eighties and the local climate is projected to shift from subtropical to tropical by the end of this century (Bidegain et al., 2009).

Expansion of the agricultural frontier in Uruguay has resulted from the modernization of agricultural practices and increases in the global demand of soybeans (Urcola et al., 2015; Volante et al., 2015). This frontier is advanced by a large and fragmented group of domestic and foreign landowners (Arbeletche and Carballo, 2009). Tree plantations in Uruguay began expanding after the approval of the Forestry Law 15.939 in 1987 that defined forestry land and provided initial subsidies to cover planting costs on soils of low productivity, and generous tax reliefs for upcoming sales gains. However, trends that frame the globalization of forestry, including the introduction of fast-growing eucalypt plantations that enable high productivity and profitability in the southern hemisphere, have largely contributed to this expansion (Cubbage et al., 2007; Korhonen et al., 2014; Toppinen et al., 2010).

A parallel trend in this globalization process is the multinational forestry enterprises' increasing awareness of the roles of ecosystem benefits and community engagement that underpin their business success (Brody et al., 2006; D'Amato et al., 2015; Faggi et al., 2014). Those few enterprises that plant and manage eucalypt plantations on their own properties or leased lands in Uruguay have introduced programs that pursue synergies between plantation forestry and other rural livelihoods, including beekeeping. This tier of the local governance system

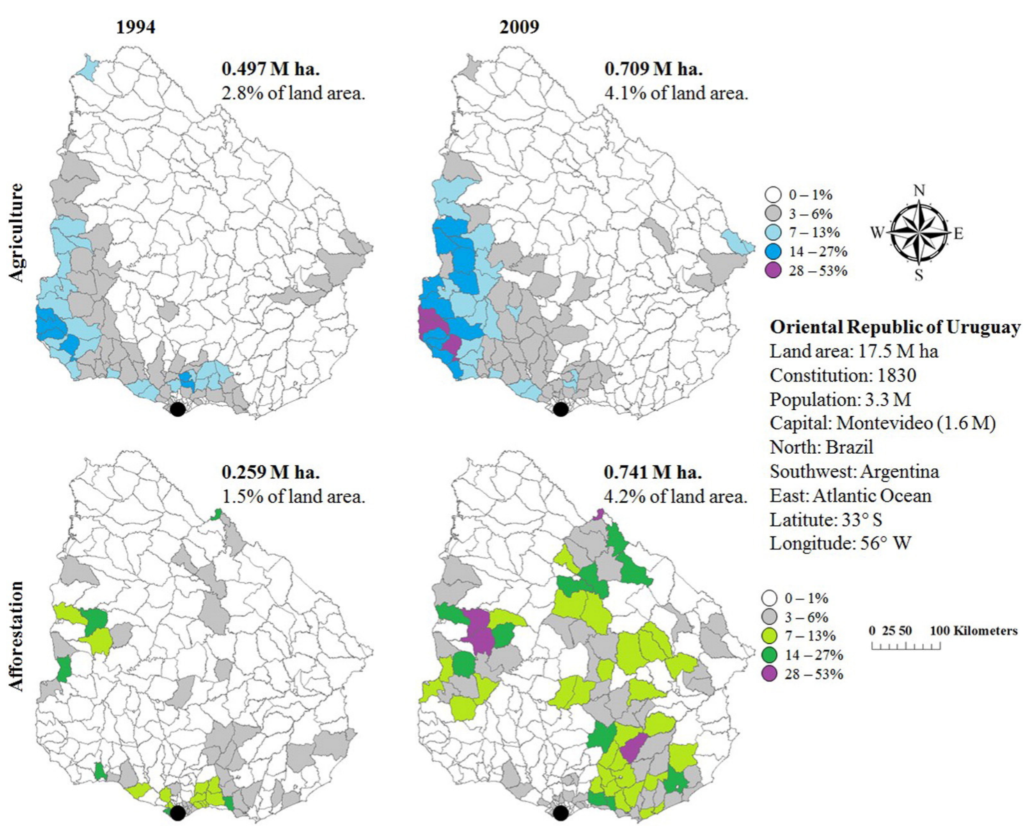

Fig. 1. Changing patterns of agriculture and afforestation in Uruguay from 1994 to 2009 (adapted from Tommasino, 2010).